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F25B 49/00

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GB 2180963 A GB 2107905 A GB 2055486 A
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UK CL (Edition K) G3N
INT CL⁵ F25B
WPI

(54) Refrigeration system with fiber optics

(57) The compressor, condenser, evaporator and associated components of a cooling system 100 are operated by various electrically powered circuits controlled by a controller 200. Signaling devices such as sensors 201, monitors 401, controllers 500, computers, microprocessors, or other devices establish control conditions for the cooling system. Light transmitting elements 206, 224, 406, 506 and 510, light receiving elements 210, 228, 410, 506 and 510, and optical fibres 208, 226 and 408 provide electrical power isolation and optically link the controller and the signaling devices to operate the electrically powered circuits. A similar link 602 operates a remote display 600. The arrangement reduces interference.

In a simpler arrangement, controller 200 may be a thermostat.

Application is to a large commercial or industrial refrigerator.

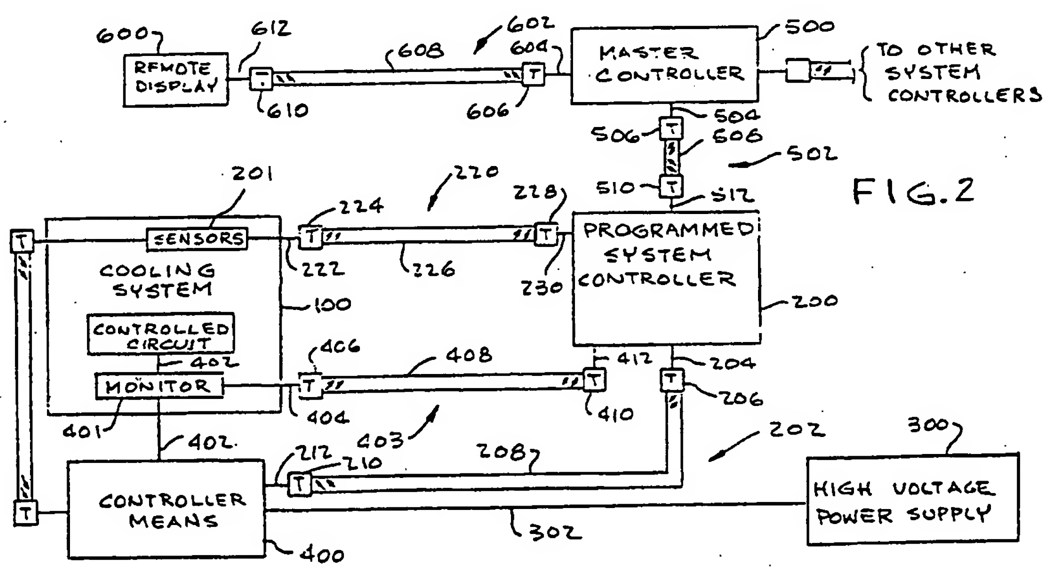

FIG.2

GB 2 232 784 A

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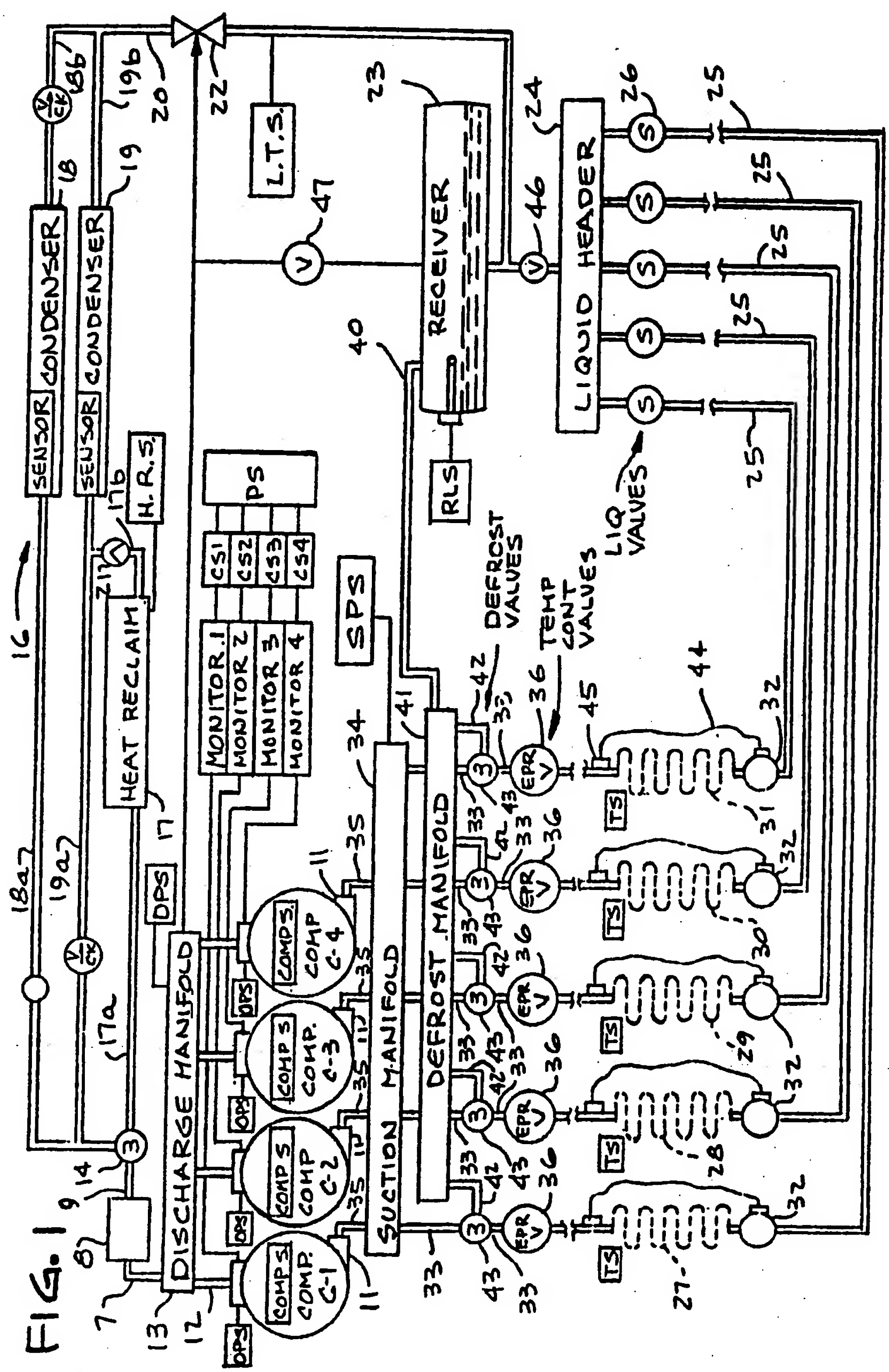
SENSOR
CONDENSER
SENSOR
CONDENSER
H.R.S.
HEAT RECLAIM
L.T.S.
RECEIVER
LIQUID HEADER
PS
CS1
CS2
CS3
CS4
MONITOR 1
MONITOR 2
MONITOR 3
MONITOR 4
SPS
RLS
DPS
DISCHARGE MANIFOLD
SUCTION MANIFOLD
DEFROST MANIFOLD
COMPS
COMP C-1
COMP C-2
COMP C-3
COMP C-4
EPR V
TS
DEFROST VALVES
TEMP CONT VALVES
LIQ VALVES
V CK

FIG. 1

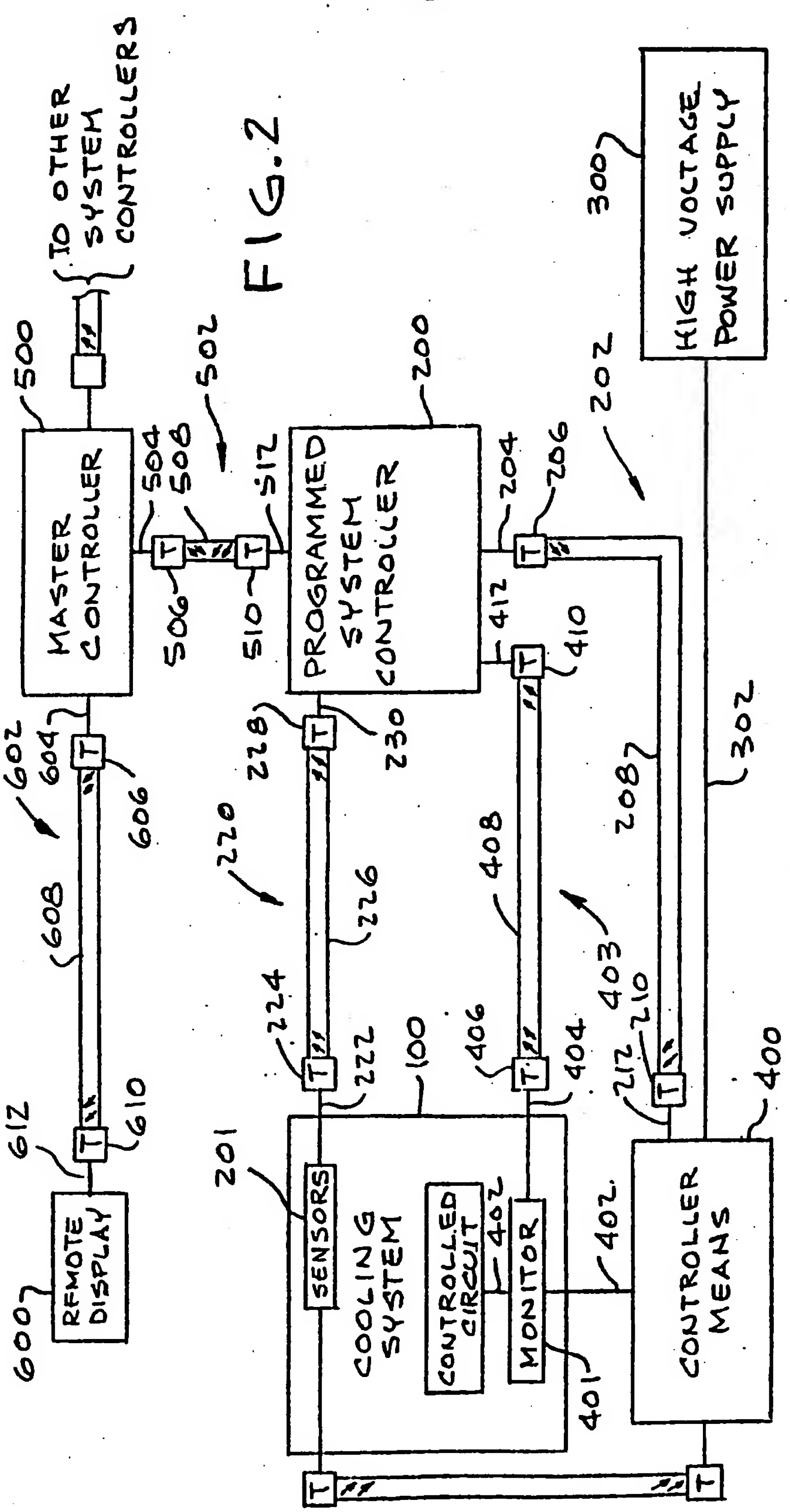
TO OTHER SYSTEM CONTROLLERS
500
MASTER CONTROLLER
502
504
506
508
510
512
200
PROGRAMMED SYSTEM CONTROLLER
202
204
206
300
HIGH VOLTAGE POWER SUPPLY
412
410
602
604
606
608
610
612
600
REMOTE DISPLAY
220
222
224
226
228
230
408
403
406
404
208
210
212
302
100
201
SENSORS
COOLING SYSTEM
CONTROLLED CIRCUIT
402
MONITOR
401
CONTROLLER MEANS
400
T

FIG.2

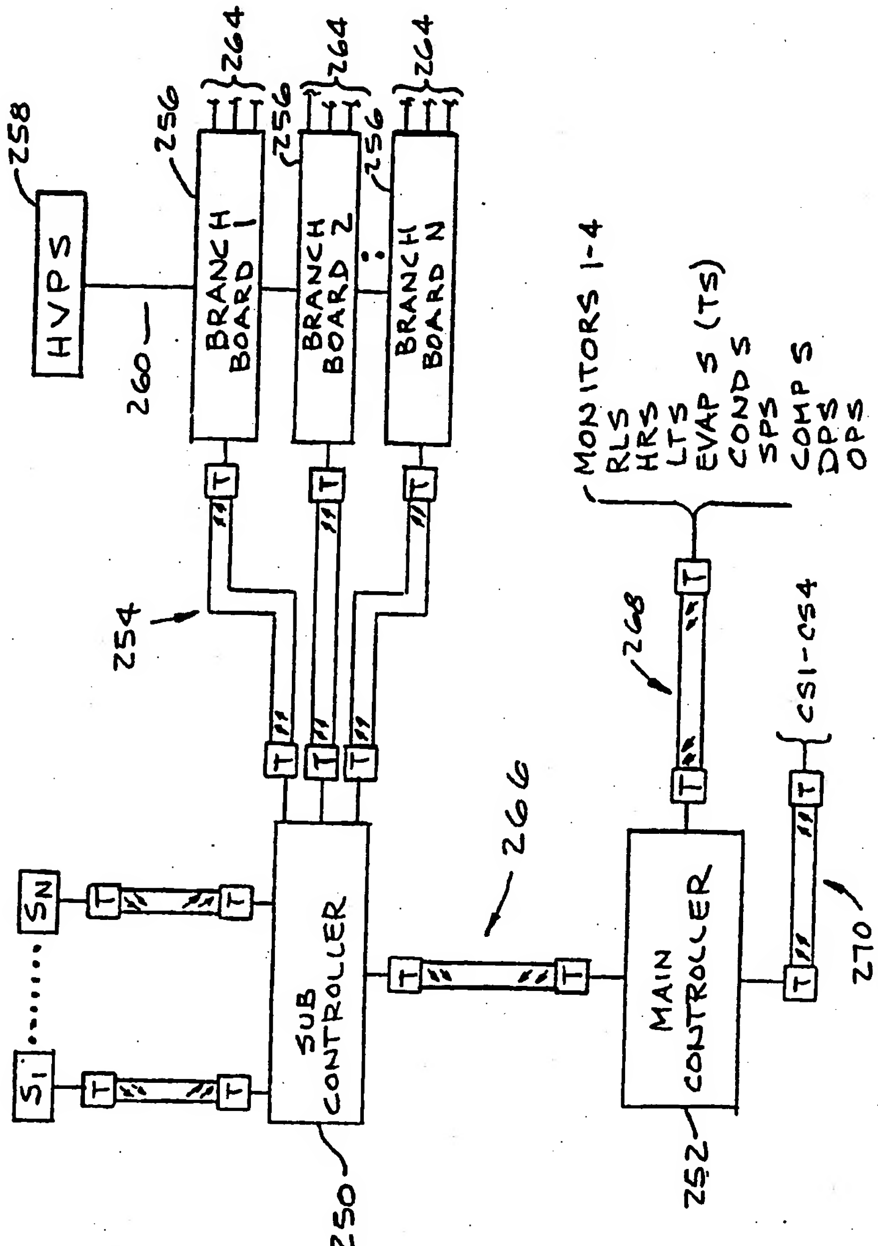
HVPS
258
260
BRANCH BOARD 1
BRANCH BOARD 2
BRANCH BOARD N
256
264
254
T
SUB CONTROLLER
250
S_1
S_N
266
MAIN CONTROLLER
252
268
270
CS1-CS4
MONITORS 1-4
RLS
HRS
LTS
EVAP S (TS)
COND S
SPS
COMP S
DPS
OPS

FIG. 3

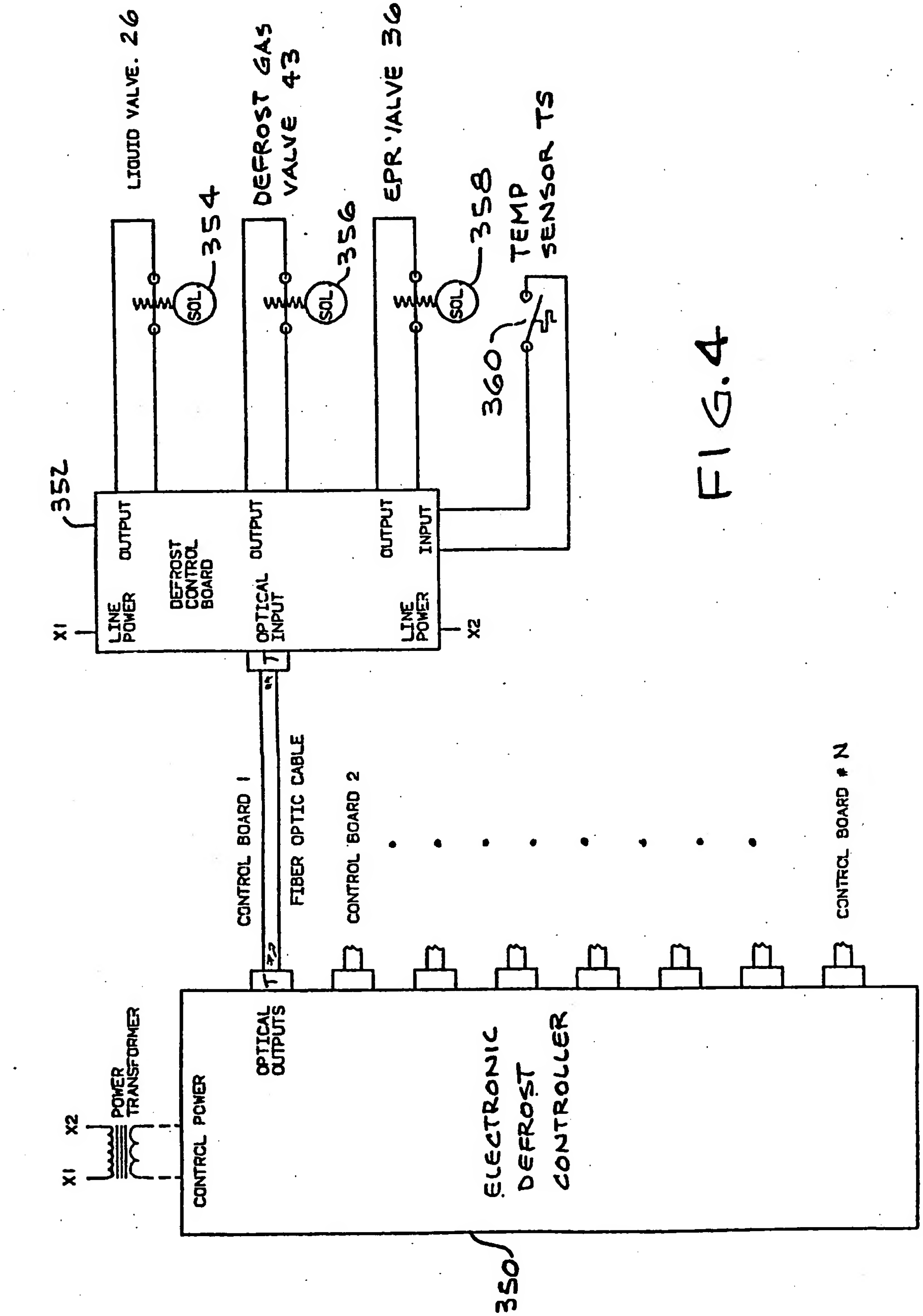
LIQUID VALVE. 26
DEFROST GAS VALVE 43
EPR VALVE 36
354
SOL
356
SOL
358
SOL
TEMP SENSOR TS
360
352
OUTPUT
DEFROST CONTROL BOARD
OUTPUT
OUTPUT
INPUT
LINE POWER
OPTICAL INPUT
LINE POWER
X1
X2
CONTROL BOARD 1
FIBER OPTIC CABLE
CONTROL BOARD 2
CONTROL BOARD # N
OPTICAL OUTPUTS
CONTROL POWER
POWER TRANSFORMER
X1
X2
ELECTRONIC DEFROST CONTROLLER
350

FIG. 4

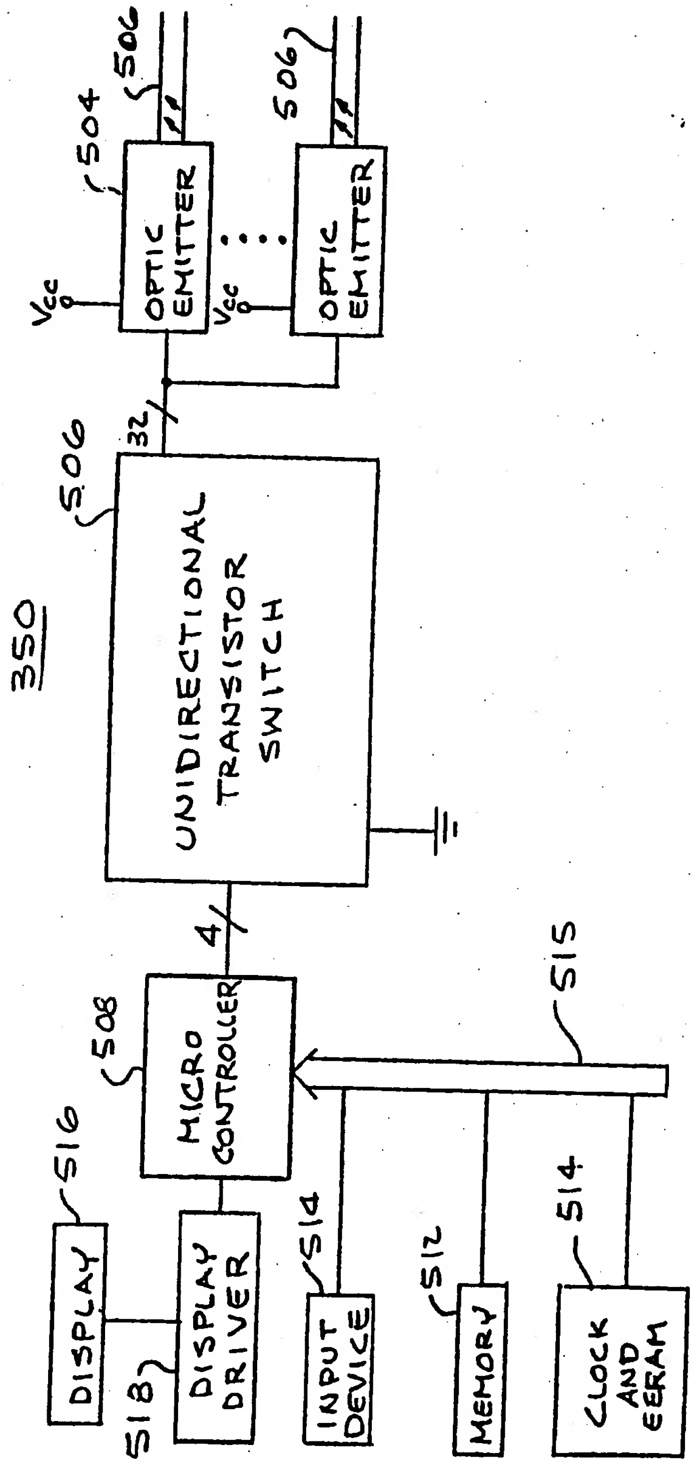
350
OPTIC EMITTER
OPTIC EMITTER
Vcc
Vcc
504
506
506
32
506
UNIDIRECTIONAL TRANSISTOR SWITCH
4
508
MICRO CONTROLLER
515
516
DISPLAY
518
DISPLAY DRIVER
514
INPUT DEVICE
512
MEMORY
514
CLOCK AND EERAM

FIG. 5

6/6

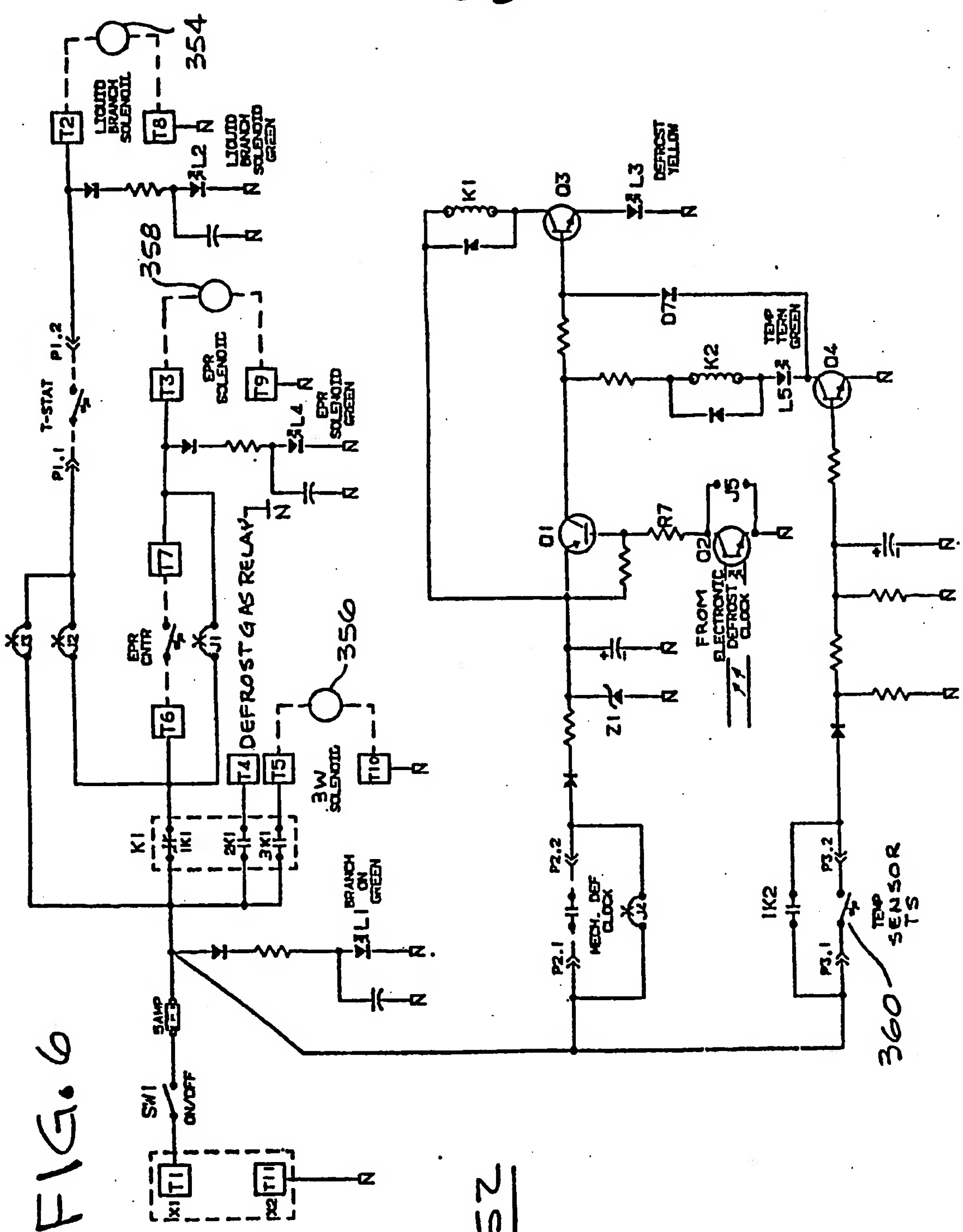
354
LIQUID BRANCH SOLENOID
LIQUID BRANCH SOLENOID GREEN
DEFROST YELLOW
358
EPR SOLENOID
EPR SOLENOID GREEN
T-STAT
P1.1
P1.2
DEFROST GAS RELAY
356
3W SOLENOID
EPR CNTR
BRANCH ON GREEN
TEMP TERM GREEN
FROM ELECTRONIC DEFROST CLOCK
MECH. DEF CLOCK
TEMP SENSOR TS
360
SW1 ON/OFF
5AMP
K1
1K1
2K1
3K1
1K2
Q1
Q2
Q3
Q4
R7
Z1
D7
K2
L1
L2
L3
L4
L5
J1
J2
J3
J4
J5
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
X1
X2
P2.1
P2.2
P3.1
P3.2

FIG. 6

352

REFRIGERATION SYSTEM WITH FIBER OPTICS

This invention relates generally to the refrigeration art, and more particularly to fiber optics in control systems for operating refrigeration systems.

Background of the Invention

Commercial refrigeration systems are used, for example, to provide the large refrigeration requirements in a supermarket installation. Industrial refrigeration systems are used, for example, for operation in refrigerated warehousing, ice plants and like installations. Environmental control systems are used, for example, for effecting the space air heating, ventilating and air conditioning in various commercial and industrial installations. These systems include electrical or electro-mechanical control apparatus for operating the system components. In commercial and industrial refrigeration systems, the control apparatus senses temperature and pressure, compressor oil levels, condensing requirements, evaporator defrost needs and the like component operating conditions. The control apparatus operates the controlled system components in response to such sensed conditions to provide efficient refrigeration while also providing safety features to compensate for compressor overloading, high and low pressure limits, low oil levels, etc. In environmental control systems, the control apparatus senses temperature and humidity conditions and operates the controlled heating, air conditioning and/or ventilating components to provide optimum comfort levels and the like.

There is now a proliferation of controllers available for connection with such commercial and industrial

refrigeration and/or environmental control systems. Such controllers are generally part of an energy management system, which operates the entire controlled system and separate system components thereof according to environmental and/or other external parameters in order to use the system in the most efficient manner with minimum power usage. Frequently, such controllers are designed to operate several systems in a coordinated manner in order to achieve a particular, desired result. For instance, a remote or master controller having a microprocessor may be programmed to operate all refrigeration systems in a supermarket installation, and also efficiently operate the environmental air handler package containing heating and air conditioning for controlling the temperature and humidity of the store's space air.

With the need for increased efficiency, refrigeration systems have become more and more complex requiring multiple control apparatus and systems and multiple sensing devices. This additional complexity makes it difficult to design a refrigeration system which has complete flexibility so that the system can be conformed to operate in various environments and in combination with other systems. In some cases, this addition of complex features has resulted in incompatible or competing requirements which are difficult to resolve without significant compromises.

Heretofore, electronic systems for commercial refrigeration and the like have been hard wired - the controllers have been hard wired directly to the various controlled components, and the sensors or other systems providing information to the controllers have been hard wired directly to the controllers. This results in controllers most frequently being subjected to noise caused by the extensive high voltage wiring used in the system and by the switching of the system components, such as compressors, condenser fans, etc. The high voltages carried by the wiring

and transients caused by switching tend to generate electromagnetic and radio frequency interference which adversely affects operation of the controllers. Such interference may generate false signals or block out signals to or from the controller, which results in unreliable, inefficient and unpredictable operation.

It is now recognized that programmed controllers should be electrically isolated from the high voltages of the refrigeration system to provide noise immunity to the controllers. In the past, such isolation has been accomplished by employing transformers or other components which provide electrical isolation while maintaining direct electrical control. Unfortunately, such isolation has been expensive, is inflexible and does not satisfactorily eliminate interference and, in fact, may contribute to it.

Summary of the Invention

Among the several objects of the invention may be noted the provision of a system for employing an electronic control for controlling inputs and outputs in refrigerations systems which employ extensive, high voltage wiring; the provision of a control for a refrigeration system which is immune to noise and does not have to be continually proven to be noise immune in each new application; the provision of a control for a refrigeration system which permits additional, optional controls to be added without affecting the noise immunity of the system at any time; the provision of a control for a refrigeration system which eliminates the paths which carry noise into the control so that the need to design and test the control for noise immunity is eliminated; the provision of a control for a refrigeration system which has immunity to electromagnetic interference and radio frequency interference, which has no signal radiation or noise

emissions, and which is immune to lightening surge currents and transients; the provision of a control for a refrigeration system which eliminates sparking so that it is not a fire hazard, which provides electrical isolation from high voltage and which provides short circuit protection; the and the provision of a control for a refrigeration system which is rugged, light in weight, cost effective and employs small cabling.

Brief Description of the Drawings

Figure 1 is a diagrammatic illustration of a typical multiple compressor refrigeration system in which the invention is embodied.

Figure 2 is a block diagram of one embodiment of a refrigeration system with a fiber optic isolated control according to the invention.

Figure 3 is a block diagram of one embodiment of system controller and power switching devices according to the invention.

Figure 4 is a block diagram of one embodiment of an electronic defrost controller and defrost control board according to the invention.

Figure 5 is a block diagram of the electronic defrost controller of Figure 4.

Figure 6 is a schematic diagram of the defrost control board of Figure 4.

Description of the Preferred Embodiments

The present invention is embodied in fiber optic control apparatus for refrigeration systems, especially of the commercial or industrial type. Therefore, with reference to Figure 1 for disclosure and environmental purposes, a

central refrigeration system is illustrated as being of the commercial multiplexed type having a plurality of parallel compressors (at least two) as installed in a supermarket food store for operating a multiplicity of separate refrigerated fixtures, such as food storage and display cases. It will be understood by those skilled in the refrigeration art that such a system may be adapted to other commercial and industrial applications having large refrigeration requirements. The term "high side" is used herein in a conventional refrigeration sense to mean the portion of the system from the compressor discharge to the evaporator expansion valves, and the term "low side" means the portion of the system from the expansion valves to the compressor suction.

The central refrigeration system of Figure 1 includes four parallel compressors C-1, C-2, C-3 and C-4, each of which has a suction port or low side refrigerant intake 11 operating within a range of preselected suction pressures and a high side discharge outlet 12 connected to a common discharge manifold 13 through which hot compressed gaseous refrigerant is discharged for condensing. Oil pressure in each compressor may be monitored by an oil pressure sensor (OPS) and the pressure in discharge manifold may be monitored by a discharge pressure sensor (DPS). The discharge manifold 13 is connected by conduit 7 to an oil separator 8, as shown for instance in U.S. patent Nos. 4,478,050; 4,503,685; 4,506,523; and 4,589,263, in which the miscible oil entrained during compression is separated from the high side refrigerant vapor for return to the compressors C1-C4. The separated discharge vapor passes through conduit 9 to a three-way reversing valve 14 for selective operation to connect directly to an outdoor or roof-top condenser 16 or to an indoor heat reclaim coil 17 in an air handler unit (not shown). The outdoor condenser 16 has split coil sections 18 and 19 connected by branch inlet lines 18a and 19a to the

three-way valve 14, and branch outlet lines 18b and 19b connect the coil sections 18 and 19 to a condensate outflow conduit 20. The heat reclaim coil 17 has an inlet line or conduit 17a connected to the three-way valve 14, and an outlet line 17b connected through a one-way check valve 21 to the inlet side 19a of one of the condenser coil sections 19. It will be understood that the heat reclaim coil 17 is selectively operable during the winter heating season to recover the compressor superheat from refrigerant vapor for use in heating space air delivered by an air handler to the supermarket or like building, but that the actual or final condensing temperature of the refrigerant is reached in the outdoor condenser 16. A fuller discussion of heat reclaim condensers is contained in U.S. patent Nos. 3,358,469 and 4,711,094.

The refrigerant is reduced to its condensing temperature and pressure by ambient air flow through the condenser 16, and the condensate outflow line 20 may be provided with a conventional flooding valve 22 to produce variable condenser back flooding for maintaining compressor head pressures at or above a preselected minimum as may be required during cold weather operations. The condensate conduit 20 is connected to a receiver 23 and outflow liquid header 24 forming a liquid refrigerant source for operating the system. Although a surge receiver 23 is disclosed, the receiver 23 may be either of the surge or flow-though type. The liquid header 24 has branch liquid lines 25 connected through solenoid valves 26 to the evaporator coils 27, 28, 29, 30 and 31 associated with different refrigerated fixtures or units (not shown) and being representative of numerous evaporators that may be connected into the refrigeration system. The inlet of each evaporator coil (27-31) is controlled by a thermostatic expansion valve 32, which meters refrigerant into its associated evaporator in a conv ntional

manner. The outlets of the evaporators are connected by branch suction lines or conduits 33 to a suction manifold 34 in turn connected by suction lines 35 to the suction side 11 of the compressors C-1, C-2, C-3 and C-4. Evaporator pressure regulator (EPR) valves 36 are shown interposed in the branch suction conduits 33 to illustrate that the suction pressure on the evaporator coils 27-32 can be adjusted so that the respective refrigerated fixtures can operate at different temperatures within the range of suction pressures established by the compressors.

The refrigeration system thus far described operates in a conventional manner in that each fixture evaporator (27-31) absorbs heat from the unit or its product load thereby heating and vaporizing the refrigerant and resulting in the formation of frost or ice on the evaporator coils. These fixture evaporators 27-31 may be selectively defrosted as periodically required by electric or gas defrost. A typical gas defrost utilizes saturated gas taken from the top of a surge receiver 23. A main gas defrost line 40 connects the receiver 23 to a defrost manifold 41, which is connected by branch defrost lines 42 to three-way defrost valves 43 interposed in the respective branch suction lines 33 from the evaporator coils 27-31. In the defrosting operation, an electrical defrost time sequencer (as discussed below) reverses the three-way defrost valve 43 to a selected evaporator (27-31) to disconnect the branch suction line 33 from the suction manifold 34 and connect it to the defrost manifold 41 so that saturated gas from the receiver 23 flows through the line 40, manifold 41, branch conduit 42 and three-way valve 43 counterflow into the selected evaporator coil for heating and defrosting such coil thereby condensing the refrigerant as in a typical condenser. A by-passs line 44 with a check valve 45 is provided around the expansion valve 32, and defrost condensate is thus returned through

branch liquid line 25 to the liquid manifold 24 for use in the normal refrigeration mode of the other (non-defrosting) evaporators. A pressure reducing valve 46 may be employed for reducing the pressure in the liquid manifold 24, and a pressure control valve 47 may be used for controlling the receiver pressure to provide a defrost gas flow incentive, as will be understood from U.S. patent Nos. 3,150,498 and 4,522,037.

Referring now to Figure 2, in its simplest form the refrigeration system according to the invention comprises a cooling system 100 including a compressor, condenser and evaporator. In commercial and industrial applications, as described with reference to Figure 1, such refrigeration systems generally have a plurality of parallel compressors and evaporators with one or more condensers and other features for cooling separate zones associated with the evaporator. In some commercial applications as well as domestic refrigeration, cooling system 100 may be a single compressor unit with associated condenser and evaporator specifically sized for cooling a dedicated fixture or zone so that it is maintained within a certain temperature range.

In any case, cooling system 100 is responsive to some type of programmed system controller 200 which controls the operation of the cooling system 100. Controller 200 constitutes other means for establishing operational control parameters of the cooling system. In domestic or household applications, programmed system controller 200 may be as simple as a thermostat for cycling the refrigeration system 100 on and off in response to temperature variations. In more sophisticated installations, such as commercial and industrial applications where a multiple compressor system is being employed, system controller 200 comprises a plurality of time sequences, microprocessors and/or other controls responsive to sensors 201 and monitors 401 which are

associated with the cooling system 100 and which sense and/or monitor operational conditions within the cooling system.

In particular, high voltage power supply 300 is selectively applied to components of the cooling system 100 by power switching devices 400, which are responsive to programmed system controller 200. Devices 400 constitute controller means for operating controlled circuits. In simple applications, system controller 200 may simply open and close power switching devices 400 to apply high voltage power from power supply 300 to one or more compressors of the cooling system. In more complex systems where preset cycling and/or defrosting are utilized, power switching devices 400 may be a bank of controller switches which selectively actuate controlled circuits to operate compressor motors or capacity unloaders, condenser fans, valves, relays or other contacts of cooling system 100 to control the particular operating cycle of the cooling system. In any case, the program in the controller establishes the operational control parameters of the cooling system. These parameters may be based on a particular clock or timing sequencer or may be derived from one or more algorithms responsive to system conditions.

System controller 200, according to the invention, is a low voltage system such as a microprocessor or computer which may be programmed and used to control the operation of refrigeration system 100. Sensors 201 and monitors 401 are also low voltage devices. In contrast, power switching controllers 400 and the circuit components of refrigeration system 100 which are being controlled or switched are generally operating on the high voltage provided by power supply 300. It is deemed necessary to electrically isolate system controller 200 from high voltage power supply 300, power switching devices 400 and refrigeration system 100 and its controlled circuits to prevent electromagnetic interference thereb tween.

In order to accomplish this isolation yet maintain communication and control between the refrigeration system 100 and the sensors, monitors and system controller, the invention contemplates optically interconnecting the system controller 200 with the power switching devices, sensors and monitors of the refrigeration system to provide electrical isolation whenever necessary or desirable. Reference character 302 refers to a high voltage conductor which provides high voltage power from power supply 300 to power switching devices 400. In contrast, reference character 202 refers to an optical fiber interconnection or transmission path link between system controller 200 and power switching devices 400. In particular, electrical conductor means 204 connect an internal circuit board of system controller 200 and electro-optic transducer 206 for transmitting control signals. Electro-optic transducer 206 converts electrical signals into light for transmission by optical fiber 208. The other end of optical fiber 208 is optically connected to opto-electric transducer 210 which converts light transmitted by the optical fiber 208 into electrical signals which are supplied to electrical conductor 212 and power switching devices 400. Consequently, system controller 200 is electrically isolated from the high voltage power supply 300 while system controller 200 is optically connected to the power switching devices 400 to control operation of the devices.

Similarly, the invention contemplates that sensors 201 for monitoring operation of refrigeration system 100 may be electrically isolated from and optically connected to system controller 200 in the same manner. Specifically, fiber.optic link 220 comprises the combination of an electrical conductor 222, electro-optical transducer 224, optical fiber 226, opto-electric transducer 28 and electrical conductor 230 for interconnecting refrigeration system 100 to system controller 200.

System controller 200 may also monitor signals being applied to refrigeration system 100 by power switching devices 400. In general, the power switching controllers 400 would be electrically connected by electrical conductor 402 to controlled circuits having operating components of the refrigeration system 100. In fact, power switching devices 400 may be an integral part of refrigeration system 100. However, for simplicity, power switching controllers 400 are illustrated separately. In order to monitor current and/or voltage being applied to one or more of the controlled circuits or components of refrigeration system 100 by power switching devices 400, monitor 401 may be located in series (or parallel) with conductor 402 to generate a monitoring signal indicating the current or voltage being applied to one or more of the controlled circuits or components of refrigeration system 100. This monitoring signal would be transmitted to controller 200 by fiber optic link 403 comprising electrical conductor 404, electro-optical transducer 406, optical fiber 408, opto-electric transducer 410 and electrical conductor 412, which provides a corresponding electrical signal to system controller 200.

In more sophisticated systems, the invention also contemplates that system controller 200 may communicate with master controller 500 which controls other refrigeration systems as well as heating, air conditioning or ventilating systems. For example, system controller 200 may be used to control a refrigeration rack in a commercial installation for a supermarket and may communicate with master controller 500 which coordinates operation of the rack with other heating, ventilating and air conditioning systems of the supermarket by coordinating operation of system controller 200 with other system controllers. In any case, in order to provide isolation between the system controller and master controller 500, the invention contemplates a fiber optic link 502 comprising

an electrical conductor 504, transducer 506, optical fiber 508, transducer 510 and electrical conductor 512 which interconnects master controller 500 with system controller 200. Preferably, fiber optic link 502 provides a bi-directional communication line between master controller 500 and system controller 200 in which case transducers 506 and 510 function as both opto-electric and electro-optic transducers. In general, the invention contemplates that any of the fiber optic links may be multiplexed and/or bi-directional or may be an optical trunk with attenuators and/or splitters. For clarity, many of the links are described as unidirectional to illustrate the primary transmission direction of information.

In one aspect of the system according to the invention, programmed system controller 200 would function as a mass communications port and data logger. Separate subcontrollers, such as a defrost controller and compressor, a controller, would be provided for each subsystem. In this way, malfunctioning of a subsystem controller would not necessarily disable the operation of the entire system.

Remote display 600 may display information provided by master controller 500 or system controller 200. Once again, the invention contemplates a fiber optic link 602 comprising electrical conductor 604, electro-optic transducer 606, optical fiber 608, opto-electric transducer 610 and electrical conductor 612 interconnecting the remote display 600 with the master controller 500. A fiber optic link (not shown) may also be used to directly interconnect a remote display 600 with system controller 200.

The invention also contemplates that the fiber optic cables may be used to create a display by projecting the status of indicators onto a face plate or panel. In this case, the light source generating the light signals would have to be visible light in order to be the simplest design possible. The sources of visible light would be part of the

electronic control or may be split from optical lights which carry control signals. Display of the light signal at the other end of the fiber would be by use of a diffusing lens such as a plastic diffusing lens. This would permit flexibility of mounting of the electronic control.

Even though the fiber optic links, such as fiber optic link 202, may be adjacent to one another and to one or more of the electrical conductors, such as conductor 302, control signals provided by system controller 200 via the fiber optic links are noise-immune and are not subject to interference by signals carried or generated by the electrical conductors, power switching devices 400, control circuits within refrigeration system 100 or other noise sources. Accordingly, the system according to the invention permits the refrigeration system 100 to employ, for example, high inductance motors which may be controlled by microprocessor based devices such as system controller 200. In general, such microprocessor devices are highly susceptible to electromagnetic noise. However, the fiber optic linking according to the invention eliminates this susceptibility.

In general, it should be noted that the fiber optic interface between system controller 200 and other parts of the system can be applied to all controls used in the refrigeration control panel. This is because of the noise immunity and electrical isolation which is achieved by the fiber optic links.

A fiber optic cable consists of an inner core, an outer coating called cladding and sometimes a protective overall jacket. Materials used for the core and cladding can be either plastic or silica (glass). Multiple fibers, usually without a jacket, can be bundled together in one jacket in the same way as a standard multiconductor cable. The core fibers offer the most rugged construction and are preferred for use as part of the invention. Due to its lower cost, multimode step ind x cables ar preferred.

The invention eliminates the electrical conductors connected to controller 200 which result in paths for supplying noise to controller 200. Generally, such electrical noise may be electromagnetic or radio frequency interference caused by other electrical conductors in the vicinity of conductors connected to controller 200. Consequently, the need for constantly designing and testing system controller 200 for noise immunity is eliminated. On current electronic refrigeration controls, the primary type of connection made is that of low voltage signals provided by a controller to relays such as power switching devices 400 for high voltage switching. The fiber optic links of the invention transmit light corresponding to the low voltage signals provided by system controller 200 to the high voltage power switching devices. There are no other connections made that are common between the system controller 200 and the high voltage power. Consequently, the high voltage power provided by supply 300 and electrical conductor 302 and supplied to system 100 by conductor 402 can be any voltage and is isolated from controller 200.

Input connections to the electronic controller 200 can also be potential points for noise input to the control because of the required cables for connection of the controller to sensors such as sensors 201. Sensors most commonly used in refrigeration control are pressure transducers, temperature probes and dry relay contacts. If HVAC is being controlled simultaneously, then humidistats and enthalpy controls may also be supplying information to system controller 200. Optical links such as fiber optic links 220 and 403 provide system controller 200 with the necessary input information without the attendant introduction of possible electrical noise. No other common connections exist between the monitoring or sensoring elements and system controller 200.

Connecting the system controller 200 by fiber optic links to other parts of the system also reduces the number of connections between controller 200 and the remaining portions of the system. In general, only one optical fiber is necessary to interconnect system controller 200 with a component such as a relay, sensor 201, monitor 403 or other controlled circuit. In contrast, conventional electrical conductors which interconnect system controllers with controlled circuits of a refrigeration system generally require multiple conductor configurations. As a result, there is a significantly lower cost associated with fiber optic linking according to the invention. With traditional conductor interconnection, controller 200 must have enough relays to accommodate a maximum number of outputs to be controlled. When some number of outputs less than the maximum number are used, there are unused relay outputs. The cost of unused fiber optic outputs on a controller according to the invention is much lower than unused relay outputs.

Figure 3 illustrates in block diagram form one embodiment of a system controller 200 comprising a subcontroller 250 and main controller 252. Fiber optic links 254 interconnect subcontroller 250 with a plurality of N branch boards, one each corresponding to the various controlled circuits, such as a compressor switch or a set of evaporating coil defrost valves. Power is supplied to each of the branch boards 256 from high voltage power supply 258 through electrical connection 260. Each of the branch boards controls various circuits of the refrigeration system. In general, conductors 264 supply a high voltage signal from power supply 258 to each of the controlled circuits in response to control signals provided by subcontroller 250 which are transmitted as optical control signals by optical link 254. These optical control signals are converted to electrical signals which open and close relays of the branch boards to selectively

apply power from source 258 to the controlled circuits to activate or deactivate their operation.

Subcontroller 250 may also receive information from the refrigeration system being controlled. For example, fiber optic links 272 may connect sensors S_1-S_N to subcontroller 250 and provide information indicating the status of the refrigeration system. In particular, sensors S_1-S_N may be temperature sensors TS indicating the temperature of each of the evaporator coils.

It is also contemplated that subcontroller 250 may be connected by fiber optic link 266 to main controller 252. Main controller 252 receives information regarding the status of the refrigeration system via optical link 268. This optical link would be connected to the sensors which monitor operation of the refrigeration system such as the current or voltage monitors 1-4, discharge manifold pressure sensor (DPS), receiver level sensor (RLS), heat reclaim sensor (HRS), liquid temperature sensor (LTS), evaporator sensors (EVAP S) such as a temperature sensor (TS), condenser sensor (COND S), suction presser sensor (SPS), oil pressure sensor (OPS) and compressor sensor (COMP S).

In addition, main controller 250 or another subcontroller may provide control signals via fiber optic link 270 to open or close compressor switches CS1-CS4 thereby turning the compressors on or off. It is also contemplated that such control signals may be provided to branch boards for controlling relay operation.

Figure 4 is a block diagram of one embodiment of a subcontroller with branch boards. In particular, Figure 4 illustrates an electronic defrost controller 350 for controlling a plurality of defrost control boards 352. In order to provide isolation and noise immunity to electronic defrost controller 350, the controller is interconnected with the defrost control boards 352 by fiber optic cables 354. Each

defrost control board 352 is associated with the various valves and temperature sensors of a particular evaporator coil to control its defrosting. Specifically, the output of defrost control board 352 is connected to a plurality of controlled circuits which actuate and deactuate valves. Solenoid 354 constitutes a controlled circuit for actuating and deactuating liquid valve 26. Solenoid 356 constitutes a controlled circuit for activating or deactivating defrost valve 43 to provide gas defrosting to the evaporator coil. Solenoid 358 constitutes a controlled circuit for optionally actuating and deactuating EPR valve 36. Temperature sensor 360 provides an input to the control board relating to the temperature of the particular evaporator coil.

Figure 5 is a block diagram of the electronic defrost controller 350 of Figure 4. The outputs of the defrost controller 350 are light signals generated by fiber optic emitters 504 that are connected by fiber optic links 506 to transmit the light signals to the various defrost branch boards 352 (shown in Figures 4 and 6). The emitters 504 are individually controlled by a unidirectional transistor switch 506 such as a UCN5832 integrated circuit having selectively grounded, open collector Darlington outputs. Microcontroller 508, such as an 80C31BH, activates emitters according to the program defrost sequence provided via bus 515 and stored in external memory 512 (such as an EPROM, 27256). The actual time of day is indicated by the clock which is a part of clock and EERAM 514 (such as MK48T02B). The particular program defrost sequence is stored in memory 512 by an operator via an input device 516 such as a key pad and is indicated on display 516 by microcontroller 508 via display driver 518. For example, display 516 may be a video fluorescent indicator panel such as F1P16A6R driven by an integrated circuit such as SN75518. The particular defrost sequence depends upon th typ of refrig ration system being

controlled. The emitter output is preferably a continuous infrared emission of the 660 NANO meter band when the emitter is on. Other light wavelengths may be used for output when needed for other applications.

The visible red light signal generated is coupled into a multi-mode plastic core fiber optic cable 506 which is used as the optical link between the defrost clock 350 and the branch board 352. In one preferred embodiment, the core/cladding diameter of the cable is 1000 micrometers. A plastic jacket covers the cable for protection. Other cables such as silica core/cladding may be used when transmission distances or applications require such high efficiency cable. Light transmitted through the cable eventually reaches the branch board where the optical signal is reconverted to an electrical signal to drive a direct current coil relay.

Referring to Figure 6, a schematic of a defrost control board 352 of Figure 4, which performs the signal conversion and relay operation, is illustrated. The infrared light energy traveling along the fiber optic cable reaches the control board 352 and is applied to the base junction of optical transistor Q2. Transistor Q2 functions as an opto-electric transducer to convert optical signals into electrical signals and is a high-gain Darlington NPN equivalent device. Transistor Q2 will turn on and saturate when light in the 200 NM to 1200 NM range is applied to its base junction. The collector of Q2 is connected to the base circuit of a PNP transistor switch Q1. When Q2 turns on, Q1 will also be turned on because its base will be pulled down one volt below its emitter voltage. Transistor Q1 will turn on the relay driver transistor Q3 thus energizing coil K1 and the yellow LED L3 indicating defrost cycle operation. As long as transistor Q2 has the appropriate wavelength light striking its base junction, coil K1 will be activated.

Transistor Q2 will turn off if the light being applied to its base is removed thus turning Q1 off because its base circuit will return to a level equal to its emitter voltage. As a result, transistor Q3 will turn off and coil K1 will deenergize.

Coil K1 operates contacts 1K1 which are normally closed and 2K1 and 3K1, which are normally open. Activating coil K1 begins the defrost cycle and illuminates yellow LED L3. Activating coil K1 will open contacts 1K1. If the system employs an EPR valve, opening contacts 1K1 will deactivate EPR solenoid 36 connected between terminal T3 and terminal T9 to open the EPR valve during the defrost cycle. If the system also employs an EPR controller, it is connected between terminals T6 and T7 and jumper J1 is cut so that the EPR solenoid is controlled by the EPR controller during non-defrost operations. Opening contacts 1K1 will also deactivate the EPR controller during the defrost cycle. Also, EPR solenoid LED L4, which is green, will be deenergized during the defrost cycle, indicating that the EPR solenoid is off and the EPR valve 36 is closed. Simultaneously, contacts 2K1 will close to energize terminal T4 and the defrost relay connected thereto. Simultaneously, contacts 3K1 will close to energize the three-way solenoid connected between terminals T5 and T10 to actuate 3-way valve 43. A shunt transistor circuit consisting of transistor Q4 will turn off the relay driver Q3 to bypass the optical input during temperature termination conditions, i.e., whenever evaporator coil temperature sensor TS closes the circuit between pins P3.1 and P3.2 to bypass contacts 1K2 and indicate that the temperature is above a preset level. This prevents defrosting cycle operation when the evaporator coil is above a preset temperature.

If the system being controlled includes a liquid branch valve, the liquid branch sol noid is connected between

terminals T2 and T8 and the thermostat for controlling the liquid branch valve is connected between pins P1.1 and P1.2. When gas defrost is used, jumper J2 is cut and jumper J3 is inserted to permit the thermostat and liquid branch solenoid to operate independently of the defrost cycle. When off-time defrost is used, jumper J3 is cut and jumper J2 is inserted so the the liquid branch solenoid is deactivated during the defrost cycle.

Transistor Q4 constitutes a temperature termination lockout circuit. In the event that the defrost cycle should be terminated due to high evaporator coil temperature, temperature termination switch TS between terminals P3.1 and P3.2 will close to turn on transistor Q4. This activates coil K2 and green LED L5 closing contacts 1K2 to maintain transistor Q4 on. This also pulls the base of transistor Q3 low through diode D7 deactivating coil K1. At this point, the defrost cycle is locked out and cannot be restarted until the electronic defrost clock light signal applied to transistor Q2 is interrupted and restarted. Upon interruption, coil K2 is deactuated resulting in Q4 (and L5) being turned off and contacts 1K2 resuming their normally open position.

In the event that a mechanical defrost clock is used in place of the electronic defrost clock 350 which provides light signals to activate transistor Q2, jumper J4 is cut and jumper J5 is inserted. The mechanical defrost clock is connected between pins P2.1 and P2.2. With jumper J5 in place, transistor Q1 will be on whenever the contacts of the mechanical defrost clock close to apply a voltage to the collector of Q1. Wheneven Q1 is on, the base of transistor Q3 will be supplied current so that Q3 will be on and coil K1 will be energized.

Although the jumpers have been illustrated in Figure 6 as hard-wired components, it is comtemplated that the jumpers may be controlled switches. For example, the

jumpers may be contacts controlled by a controlled circuit connected by optical link to a controller and responsive thereto.

The light signals transmitted through the fiber optic cable are similar to those conducted by conductive wires. The advantages of fiber optic cables over conductive wires are increased speed, wider band width, lower noise and low attenuation. There are four types of signaling methods which may be used as part of the invention, although it is contemplated that any type of optical signaling may be employed. The methods are continuous (DC), pulsed, pulse width modulated and serial digital data. For example, the optic emitter 504 described above as part of the defrost clock 350 could be pulsed on/off or operated as a digital serial data port. The emitter circuit described in Figure 5 could provide a stair-step output increase and infrared light emissions to create a coarse analog type of output. As described above, the invention uses a continuous infrared emission to signal the receiver. Clearly, more information can be sent by using a pulse format because the time duration variable is now available. The current emitter circuit can generate pulses and control the frequency and/or pulse width easily. The existing bistable latches can be selectively written logic ones and logic zeros alternately, resulting in the toggling of the driver transistors which in turn will effectively pulse the optical emitters. The control program could vary the rate and pattern of the ones and zeros to the latch in order to code the signal as desired. Alternatively, a pulse width modulator circuit could be employed to provide the necessary toggling signal to the optical emitter drivers according to microprocessor commands or any type of varying signal.

The receiving branch board would convert the pulsed infrared signal using the same method of Q2 switching

described above in the defrost control board. The Q1 and Q3 circuits would be replaced by a pulse code decoder to reconstruct the command sent by the microcontroller or the varying signal in the transmitting part of the control. This decoder could be, for example, a simple binary ripple counter or a frequency counter or an integrator circuit. Processing of these reconstructed signals could then be accomplished by any common means to provide the necessary board function.

In the same manner that common serial communications are accomplished using conductive wires, the programmed controller of the invention can operate a serial data port. The output of the serial port would connect to the infrared emitted driver circuit and create the optical serial data. This data would travel down the fiber optic cable to the control board. The infrared light reaching the receiver will be converted to standard electrical serial data by Q2. The reconstructed serial data could then be handled as common serial data to communicate the command sent by the programmed controller causing the necessary board function to occur.

The amount of infrared power launched (emitted) by the emitter is a direct function of the forward current (I_f) through the device. An amplifier circuit may be used to vary the amount of emitter current (I_f) based on a command from the programmed controller or a varying input signal. The operation would be similar in nature to changing the value of the current limit resistor. The amount of launched power could be raised or lowered depending on the new current limit resistance value. An optical visible red emitter does not offer fine control over launched power because of the nature of the component. Coarse variations are, however, possible so that this type of control is of value. The receiver end of the control will be the optical transistor circuit.

The concept of feedback from the receiver to the originating transmitter, such as for the purpose of error

detection and verification of the action taken as a result of the signal sent, is also contemplated by the invention. This can be applied to the fiber optic links described so far by either of the following techniques. First of all, a second fiber optic cable can be added to interconnect the receiver to the sending control. The feedback information would then be transmitted to a receiver on the sending control. The emitter and receiver circuits used for the feedback link could be of any of the designs described above. Second of all, the same optical fiber as used for the initial transmission can also be used. The use of an optical 2/1 multiplexer would allow for the switching between the required emitter and receiver circuits on either of the parts of the optical communication link. This means that the main control, the optical multiplexer would switch back and forth the fiber optic cable between the emitter and receiver circuits as required to support the bi-directional optical transmission.

Referring again to Figure 6, operation of the LEDs will be described. Switch SW1 cuts power to the defrost branch. The five ampere fuse in series with switch SW1 protects the entire branch board and individual mechanical clock circuits. As long as the switch is closed and the fuse is not blown, green LED L1 is illuminated to indicate that the branch board is powered. The yellow defrost LED L3 indicates when a defrost clock is controlling a defrost cycle. A 120 volt AC power signal will be present at the three-way solenoid connected to terminals T5 and T10 and the KOOLGAS relay output terminal T4 when the yellow LED L3 is illuminated. When the time clock or temperature termination thermostat 360 signals the end of the defrost cycle, LED L3 will be deactivated.

Green LED L4 is illuminated to indicate when the branch board is not in a defrost cycle. As indicated above,

an optional EPR thermostat control may be connected between terminals T6 and T7 and by cutting jumper J1. When the control is closed, the EPR LED L4 will be on and 120 volts AC power will be present at the EPR solenoid output terminals T3 and T9. If the EPR control opens or the defrost clock begins a defrost cycle to open contacts 1K1, LED L4 will be deactivated and the 120 volt AC power will be removed.

Green LED L2 is illuminated to indicate when the temperature thermostat connected between pins P1.1 and P1.2 is closed, calling for refrigeration to be started. A 120 volt AC power signal will be present at the liquid branch solenoid output terminals T2 and T8. The operation during defrost cycling is selected by jumpers 1 and 2 indicated above. If jumper 3 is cut and jumper J2 is in place, then the liquid solenoid 334 will be deactivated during defrost cycles because contacts 1K1 will be open and no power will be delivered thereto. If jumper 2 is cut instead of jumper 1, then the liquid solenoid 354 will stay on during defrost cycling and operate according to the thermostat between pins P1.1 and P1.2.

Green LED L5, preferably located on the PC board, will indicate when the case defrost termination thermostat 360 is closed. This will be mainly a diagnostic LED to show when a branch is in refrigeration but the time clock still has not terminated the defrost based on time.

Claims

1. A refrigeration system comprising:

cooling means including compressor, condenser and evaporator means and associated components for cooling a zone associated with said evaporator means;

electrically powered circuit means for operating the cooling means;

controller means for controlling the circuit means;

other means for signaling control conditions for operation of said cooling means; and

light transmitting means for providing electrical power isolation and for transmitting a light signal between said controller means and said other means for operating the circuit means.

2. The refrigeration system according to claim 1, in which said light transmitting means comprises a light transmitting element having first means at one end for converting an electrical signal into a light signal for transmission by the light transmitting element and second means at the other end for converting a transmitted light signal into an electrical signal.

3. The refrigeration system of claim 1 wherein said light transmitting means comprises a light transmitting element having a first transducer at one end of the light transmitting element for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said controller means provides electrical signals to the first transducer, and wherein said electrical powered circuit means comprises a switch responsive to electrical signals provided by the second transducer for connecting said cooling means to a power supply.

4. The refrigeration system according to claim 2, in which said controller means comprises electrical switching means connected to said controlled circuit for selectively supplying electrical power to said controlled circuit.

5. The refrigeration system according to claim 4, in which said other means comprises sensing means for sensing a condition within said system, and said light transmitting means is constructed and arranged to transmit a light signal representative of the sensed condition and in which said electrical powered circuit means comprises means responsive to a transmitted light signal for use in controlling the operation of said cooling means.

6. The refrigeration system according to claim 4, in which said other means comprises monitoring means for monitoring a condition within said system, said light transmitting means is constructed and arranged to transmit a light signal representative of the monitored condition and said electrical switching means comprises means responsive to a transmitted light signal for use in controlling the operation of said cooling means.

7. The refrigeration system according to claim 4, in which said other means comprises a programmed system controller for specifying control conditions of said cooling means and said light transmitting means is constructed and arranged to transmit a light signal representative of the specified condition and said electrical switching means comprises means responsive to a transmitted light signal for use in controlling the operation of said cooling means.

8. The refrigeration system according to claim 4, in which said other means includes timer means for indicating predetermined periodic operations of said cooling means, and said light transmitting means transmits timing data from said timing means to said controller means.

9. The refrigeration system according to claim 8, in which said timer means includes defrost means for periodically defrosting said evaporator means.

10. The refrigeration system of claim 1 further comprising means for electrically connecting a power supply to said electrical powered circuit means and wherein said electrically connecting means are located adjacent to the light transmitting means.

11. The refrigeration system of claim 1 further comprising means for remotely displaying information representative of the status of the refrigeration system and second light transmitting means for providing electrical power isolation and for transmitting a light signal between said remotely displaying means and said controller means.

12. The refrigeration system of claim 1 furth r comprising means for coordinating operation of said controller means with another controller and means for providing electrical power isolation and for transmitting a light signal between said coordinating means and said other controller means.

13. The refrigeration system of claim 1 wherein said cooling means comprises a refrigerant flow control system for moving refrigerant fluid including a condenser for condensing the refrigerant fluid to a saturated state for absorbing heat from the zone and returning low pressure refrigerant vapor from the zone and retaining a compressor for compressing the refrigerant vapor to a high pressure state and providing the compressed vapor to the condenser.

14. The refrigeration system of claim 13 wherein said light transmitting means comprises a light transmitting element having a first transducer at one end of the light transmitting element for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said other means provide electrical signals to the first transducer, and wherein said controller means comprises a switch responsive to electrical signals provided by the second transducer for connecting said cooling means to a power supply.

15. The refrigeration system of claim 14 wherein said associated components of the cooling means include a pressure regulating valve responsive to electrical signals from the second transducer.

16. The refrigeration system of claim 14 wherein and wherein said associated components of the cooling means includes a flow regulating valve responsive to electrical signals from the second transducer.

17. The refrigeration system of claim 14 wherein said cooling means comprises means for defrosting said evaporator responsive to electrical signals from the second transducer.

18. The refrigeration system according to claim 17 wherein said defrosting means comprises a gas defrost manifold downstream of said compressor, valve means for selectively connecting said defrost manifold to said evaporator for supplying defrosting gas thereto, and wherein said valve means are responsive to the electrical signals from the second transducer.

19. The refrigeration system according to claim 18 wherein said cooling means includes a receiver for storing condensed refrigerant, said defrost manifold is connected to receive saturated vapor from said receiver and said valve means selectively control the flow of liquid refrigerant to said evaporator for normal cooling and the flow of vapor from said manifold for defrosting.

20. The refrigeration system of claim 13 wh rein said circuit means electrically connects a power supply to the compressor, and further comprising a monitor associated with the circuit means for measuring a parameter of the electrical power supplied to the compressor, and wherein said light transmitting means comprises a light transmitting element having a first transducer at one end for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said monitor provides electrical signals representative of the monitored parameter to the first transducer, and wherein said controller means is responsive to electrical signals from the second transducer.

21. A control for a refrigeration system for providing cooling comprising:

means for controlling operation of the refrigeration system;

means for supplying electrical power for the refrigeration system;

means, responsive to the controlling means, for electrically connecting the supplying means to the refrigeration system; and

means for electrically isolating and optically connecting the controlling means and the electrically connecting means.

22. A control for a refrigeration system for providing cooling and including a defrost system comprising:

means for controlling operation of the defrost system;

means for supplying electrical power for the defrost system;

means, responsive to the controlling means, for electrically connecting the supplying means to the defrost system; and

means for electrically isolating and optically connecting the controlling means and the electrically connecting means.

23. The refrigeration system of claim 22 wherein said isolating means comprises a light transmitting element having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said electrically connecting means comprises a switch responsive to electrical signals provided by the second transducer for connecting said supplying means to said cooling means.

24. The refrigeration system of claim 22 wherein the refrigeration system includes a refrigerant flow control system for moving refrigerant fluid including a condenser for condensing the refrigerant fluid to a saturated state for absorbing heat from the zone and returning low pressure refrigerant vapor from the zone and retaining a compressor for compressing the refrigerant vapor to a high pressure state and providing the compressed vapor to the condenser.

25. The refrigeration system of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said associated components of the cooling means includes a pressure regulating valve responsive to electrical signals from the second transducer.

26. The refrigeration system of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said associated components of the cooling means includes a flow regulating valve responsive to electrical signals from the second transducer.

27. The refrigeration system of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said cooling means comprises means for defrosting responsive to electrical signals from the second transducer.

28. The refrigeration system according to claim 27 wherein said defrosting means comprises a gas defrost manifold downstream of said compressor, valve means for selectively connecting said defrost manifold to said evaporator for supplying defrosting gas thereto, and wherein said valve means are responsive to the electrical signals from the second transducer.

29. The refrigeration system according to claim 28 wherein said cooling means includes a receiver for storing condensed refrigerant, said defrost manifold is connected to receive saturated vapor from said receiver and said valve means selectively control the flow of liquid refrigerant to said evaporator for normal cooling and the flow of vapor from said manifold for defrosting.

30. The refrigeration system of claim 24 wher in said electrically connecting means electrically connects the supplying means to the compressor, and further comprising a monitor associated with the electrically connecting means for measuring a parameter of the electrical power supplied to the compressor, and wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said monitor provides electrical signals representative of the monitored parameter to the first transducer, and wherein said controlling means is responsive to electrical signals from the second transducer.

31. A refrigeration system comprising:

means for cooling;

means for controlling operation of the cooling means;

means for supplying electrical power for the cooling means;

means, responsive to the controlling means, for electrically connecting the supplying means to the cooling means; and

means, associated with the cooling means, for sensing a condition of the cooling means and means for electrically isolating and optically connecting the sensing means to the controlling means.

32. A refrigeration system comprising:

means for cooling;

means for controlling operation of the cooling means;

means for supplying electrical power for the cooling means;

means, responsive to the controlling means, for electrically connecting the supplying means to the cooling means; and

means, associated with the electrically connecting means, for monitoring electrical power being supplied to the cooling means and means for electrically isolating and optically connecting the monitoring means to the controlling means.

33. In a refrigeration system having electrically powered circuit means for operating at least one system component, signaling means for establishing an operating parameter for said circuit means, and controller means for controlling such circuit means in response to said signaling means; the improvement comprising light transmitting means for providing electrical power isolation between said controller means and said signaling means and for transmitting a light signal for operating the circuit means.

34. The refrigeration system according to claim 33, in which said signaling means comprises information transmitting means selected from a group consisting of sensors, monitors, controllers, computers, and microprocessors.

35. A refrigeration system constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

36. A control for a refrigeration system constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

Amendments to the claims have been filed as follows

1. A refrigeration system comprising:

cooling means including compressor, condenser and evaporator means and associated components for cooling a zone associated with said evaporator means;

electrically powered circuit means including controlled circuit means for operating the cooling means;

controller means for controlling the circuit means;

other means for signaling control conditions for operation of said cooling means; and

light transmitting means for providing electrical power isolation between said other means and said controller means and for transmitting a light signal therebetween.

2. The refrigeration system according to claim 1, in which said light transmitting means comprises a light transmitting element having first means at one end for converting an electrical signal into a light signal for transmission by the light transmitting element and second means at the other end for converting a transmitted light signal into an electrical signal.

3. The refrigeration system of claim 1 wherein said light transmitting means comprises a light transmitting element having a first transducer at one end of the light transmitting element for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said controller means provides electrical signals to the first transducer, and wherein said electrical powered circuit means comprises a switch responsive to electrical signals provided by the second transducer for connecting said cooling means to a power supply.

4. The refrigeration system according to claim 1, in which said controller means comprises electrical switching means connected to said controlled circuit means for selectively supplying electrical power to said controlled circuit means.

5. The refrigeration system according to claim 1, in which said other means comprises sensing means for sensing a condition within said system, said light transmitting means is constructed and arranged to transmit a light signal representative of the sensed condition, and in which said electrical powered circuit means comprises means responsive to a transmitted light signal for controlling the operation of said cooling means.

6. The refrigeration system according to claim 4, in which said other means comprises monitoring means for monitoring a condition within said system, said light transmitting means is constructed and arranged to transmit a light signal representative of the monitored condition, and said electrical powered circuit means comprises responsive to a transmitted light signal for controlling the operation of said cooling m ans.

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7. The refrigeration system according to claim 1, in which said other means comprises a programmed system controller for specifying control conditions of said cooling means, said light transmitting means is constructed and arranged to transmit a light signal representative of the specified condition, and said electrical powered circuit means comprises means responsive to a transmitted light signal for controlling the operation of said cooling means.

8. The refrigeration system according to claim 4, in which said other means includes timer means for indicating predetermined periodic operating functions of said cooling means, and said light transmitting means transmits timing data from said timing means to said controller means.

9. The refrigeration system according to claim 8, in which said timer means includes defrost means for periodically defrosting said evaporator means.

10. The refrigeration system of claim 1 further comprising means for electrically connecting a power supply to said electrical powered circuit means and wherein said electrical connecting means are located adjacent to the light transmitting means.

11. The refrigeration system of claim 1 further comprising means for remotely displaying information representative of the status of the refrigeration system and second light transmitting means for providing electrical power isolation.and for transmitting a light signal between said remotely displaying means and said controller means.

12. The refrigeration system of claim 1 further comprising means for coordinating operation of said controller means with another controller, and means for providing electrical power isolation and for transmitting a light signal between said coordinating means and said other controller.

13. The refrigeration system of claim 1 wherein said cooling means comprises a refrigerant flow control system for moving refrigerant fluid in which said condenser means condenses vaporized refrigerant fluid to a saturated liquid state, said evaporator means expands the liquid refrigerant for absorbing heat from the associated zone, and said compressor means returns low pressure refrigerant vapor from the zone and compresses it to a high pressure state and discharges it to the conderser means and through the system.

14. The refrigeration system of claim 13 wherein said light transmitting means comprises a light transmitting element having a first transducer at one end of the light transmitting element for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said other means provide electrical signals to the first transducer, and wherein said controller means comprises electrical switching means responsive to electrical signals provided by the second transducer for connecting said controlled circuit means to a power supply.

15. The refrigeration system of claim 14 wherein said associated components of the cooling means include a pressure regulating valve responsive to electrical signals from the second transducer.

16. The refrigeration system of claim 14 wherein and wherein said associated components of the cooling means includes a flow regulating valve responsive to electrical signals from the second transducer.

17. The refrigeration system of claim 14 wherein said cooling means comprises means for defrosting said evaporator responsive to electrical signals from the second transducer.

18. The refrigeration system according to claim 17 wherein said defrosting means comprises a gas defrost manifold downstream of said compressor means, valve means for selectively connecting said defrost manifold to said evaporator means for supplying defrosting gas thereto, and wherein said valve means are responsive to the electrical signals from the second transducer.

19. The refrigeration system according to claim 18 wherein said cooling means includes a receiver for storing condensed refrigerant, said defrost manifold being connected to receive saturated vapor from said receiver, and said valve means including means for selectively controlling the flow of liquid refrigerant from said receiver to said evaporator means for normal cooling and the flow of vapor from said defrost manifold for defrosting.

20. The refrigeration system of claim 13 wherein said circuit means electrically connects a power supply to the compressor means, and further comprising a monitor associated with the circuit means for measuring a parameter of the electrical power supplied to the compressor means, and wherein said light transmitting means comprises a light transmitting element having a first transducer at one end for converting an electrical signal into a light signal for transmission by the element and a second transducer at the other end for converting a light signal transmitted by the element into an electrical signal, wherein said monitor provides electrical signals representative of the monitored parameter to the first transducer, and wherein said controller means is responsive to electrical signals from the second transducer.

21. A control for a refrigeration system for providing cooling comprising:

means for controlling operation of the refrigeration system;

means for supplying electrical power for the refrigeration system;

means, responsive to the controlling means, for electrically connecting the supplying means to the refrigeration system; and

means for electrically isolating and optically connecting the controlling means and the electrically connecting means.

22. A control for a refrigeration system for providing cooling and including a defrost system comprising:

means for controlling operation of the defrost system;

means for supplying electrical power for the defrost system;

means, responsive to the controlling means, for electrically connecting the supplying means to the defrost system; and

means for electrically isolating and optically connecting the controlling means and the electrically connecting means.

23. The refrigeration system control of claim 22 wherein said isolating means comprises an optical fibre having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said electrically connecting means comprises a switch responsive to electrical signals provided by the second transducer for connecting said supplying means to said cooling means.

24. The refrigeration system of claim 22 wherein the refrigeration system includes a refrigerant flow control system for moving refrigerant fluid in which said condenser means condenses vaporized refrigerant fluid to a saturated liquid state, said evaporator means expands the liquid refrigerant for absorbing heat from the associated zone, and said compressor means returns low pressure refrigerant vapor from the zone and compresses it to a high pressure state and discharges it to the condenser means and through the system.

25. The refrigeration system control of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said associated components of the cooling means includes a pressure regulating valve responsive to electrical signals from the second transducer.

26. The refrigeration system control of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said associated components of the cooling means includes a flow regulating valve responsive to electrical signals from the second transducer.

27. The refrigerationsystem control of claim 24 wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said controlling means provides electrical signals to the first transducer, and wherein said defrost system comprises means for defrosting responsive to electrical signals from the second transducer.

28. The refrigeration system control according to claim 27 wherein said defrosting means comprises a gas defrost manifold downstream of said compressor means, valve means for selectively connecting said defrost manifold to said evaporator means for supplying defrosting gas thereto, and wherein said valve means are responsive to the electrical signals from the second transducer.

29. The refrigeration system control according to claim 28 wherein said cooling means includes a receiver for storing condensed refrigerant, said defrost manifold being connected to receive saturated vapor from said receiver, and said valve means including means for selectively controlling the flow of liquid refrigerant to said evaporator means for normal cooling and the flow of vapor from said defrost manifold for defrosting.

30. The refrigeration system control of claim 24 wherein said electrically connecting means electrically connects the supplying means to the compressor means, and further comprising a monitor associated with the electrically connecting means for measuring a parameter of the electrical power supplied to the compressor means, and wherein said isolating means comprises an optical fiber having a first transducer at one end for converting electrical signals into light for transmission by the optical fiber and a second transducer at the other end for converting light transmitted by the optical fiber into an electrical signal, wherein said monitor provides electrical signals representative of the monitored parameter to the first transducer, and wherein said controlling means is responsive to electrical signals from the second transducer.

31. A refrigeration system comprising:

means for cooling;

means for controlling operation of the cooling means;

means for supplying electrical power for the cooling means;

means, responsive to the controlling means, for electrically connecting the supplying means to the cooling means; and

means, associated with the cooling means, for sensing a condition of the cooling means; and

means for electrically isolating and optically connecting the sensing means to the controlling means.

32. A refrigeration system comprising:

means for cooling;

means for controlling operation of the cooling means;

means for supplying electrical power for the cooling means;

means, responsive to the controlling means, for electrically connecting the supplying means to the cooling means; and

means, associated with the electrically connecting means, for monitoring electrical power being supplied to the cooling means ;and

means for electrically isolating and optically connecting the monitoring means to the controlling means.

33. In a refrigeration system having electrically powered circuit means for operating at least one system component, signaling means for establishing an operating parameter for said circuit means, and controller means for controlling such circuit means in response to said signaling means; the improvement comprising light transmitting means for providing electrical power isolation between said controller means and said signaling means and for transmitting a light signal for operating the circuit means.

34. The refrigeration system according to claim 33, in which said signaling means comprises information transmitting means selected from a group consisting of sensors, monitors, controllers, computers, and microprocessors.

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